Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Sustainable Cities and Society 59 (2020) 102236

Contents lists available at ScienceDirect

Sustainable Cities and Society

journal homepage: www.elsevier.com/locate/scs

Residents' awareness of the role of informal green spaces in a post-industrial city, with a focus on regulating services and urban adaptation potential

Renata Włodarczyk-Marciniak[a,*], Daria Sikorska[a,c], Kinga Krauze[a]

[a] European Regional Centre for Ecohydrology of the Polish Academy of Sciences, 3 Tylna Str., 90-364, Łódź, Poland
[c] Institute of Environmental Engineering, Department of Remote Sensing and Environmental Assessment, Warsaw University of Life Sciences - SGGW, ul. Nowoursynowska 159, 02-776, Warsaw, Poland

ARTICLE INFO

Keywords:
Informal green spaces
Perception
Urban ecosystem services
Spatial change
Redevelopment

ABSTRACT

Urban green spaces (UGS) and the ecosystem services they provide are essential for the health and wellbeing of city dwellers. UGS are increasingly seen as a potential solution for sustainable urban planning and development. Informal green spaces (IGS), even though they may make up a large share of UGS, are often overlooked in this regard. This study examines residents' awareness of the ecosystem services provided by IGS and their need for redevelopment. The data were collected through structured interviews in the immediate vicinity of selected IGS in the Polish city of Łódź. Łódź is typical of post-industrial European cities struggling with environmental (heatwaves, cloudbursts), social (aging, depopulation) and spatial (a neglected and dense city center) issues. Our results show that residents saw IGS as places able to provide a range of services, mostly of the regulating type, and even minor design interventions can improve the attractiveness of IGS. Taking this into account, we conclude that IGS are important vegetated areas in the city, which can be complementary to formal greenery.

1. Introduction

Modern society, despite the advancement of technology, relies on goods and services derived from nature – not only for mental and physical regeneration and for the cultural and educational values nature offers to humans and food provision, but also, more importantly, for clean air, soil regeneration, water purification and disaster risk reduction (Alcock, White, Wheeler, Fleming, & Depledge, 2014; Kabisch et al., 2016; Liu, Chen, & Peng, 2014; Millennium Ecosystem Assessment, 2005). One of the key challenges of the modern world is to provide these services to the growing population of cities (World Health Organization, 2016). This brings urban green spaces (UGS) to the center of attention as a premise of citizens' wellbeing (European Environment Agency, 2009, 2010a, 2012; European Environment Agency & Joint Research Centre, 2013; Kim & Miller, 2019), and a *sine qua non* for cities' long-term sustainability, built on a range of regulatory services recognized as nature-based solutions (Cohen-Shacham, Walters, Janzen, & Maginnis, 2016; European Commission, 2015). Moreover, access to UGS has become a pressing environmental-justice issue in densely populated areas (Łaszkiewicz, Kronenberg, & Marcińczak, 2018). However, city managers are confronted with multiple barriers to establishing new green spaces, mostly due to spatial and financial restrictions (Kronenberg, 2015). The most commonly desired UGS – urban parks and forests – are frequently not sufficient to meet the demand for services due to their location (usually the outskirts of city centers, or even in suburban areas) or limited size or location options, hence the role of alternative green areas has been highlighted, e.g. cemeteries (Nordh, Evensen, & Skar, 2017), allotment gardens (Soga et al., 2017), or residential greenery (Battisti, Pille, Wachtel, Larcher, & Säumel, 2019). One recently studied option involves considering various patches of vegetated areas scattered throughout the city which are not included in the city's planning documents as UGS, but provide numerous benefits to residents (walking paths and pet areas, recreational spaces, urban agriculture lots). Such places are referred to as informal green spaces (IGS). Although they are defined in various ways, in general they are all neglected areas which are not formally recognized or planned for recreational use by inhabitants (Pietrzyk-Kaszyńska, Czepkiewicz, & Kronenberg, 2017; Rupprecht & Byrne, 2014a, 2014b). It is also possible to create new green infrastructure in dense cities on urban vacant land through smart growth principles such as in-filling, brownfield and greyfield redevelopment/recycling (European Environment Agency, 2016; Kim, 2018).

From an ecological point of view, IGS have a large potential to regulate air quality, flood risk and temperature and to promote urban biodiversity (Bonthoux, Brun, Di Pietro, Greulich, & Bouché-Pillon, 2014; Brun, Di Pietro, & Bonthoux, 2018). This is due to the processes

* Corresponding author.
E-mail address: r.wlodarczyk@erce.unesco.lodz.pl (R. Włodarczyk-Marciniak).

https://doi.org/10.1016/j.scs.2020.102236
Received 25 February 2020; Received in revised form 29 April 2020; Accepted 29 April 2020
Available online 08 May 2020

of ecological succession which structurally and functionally differentiate them from man-made and artificially maintained green spaces (Kowarik, 2013; Mathey, Arndy, Banse, & Rink, 2018). IGS also have a potential to act as connectors within a larger green network, providing an ecological connectivity of green spaces as a basis for sustainable and restorative development of a city (e.g. Krauze & Wagner, 2019). Even if they are not intended for recreational use, studies show that IGS offer opportunities for spending free time (Brun et al., 2018; Kremer, Hamstead, & McPhearson, 2013; Rall & Haase, 2011; Rupprecht, Byrne, Ueda, & Lo, 2015; Unt & Bell, 2014) and enable residents to interact with nature (Rupprecht et al., 2015). Despite the rationality of increasing areas dedicated to greenery in cities to mitigate climate change effects (e.g. heatwaves and cloudbursts (Grimm et al., 2008; Depietri et al., 2012), Cortinovis et al. (2019) noted that the majority of European cities (EU) are experiencing a reduction in urban green spaces, and almost none had halted land development (European Environment Agency, 2010a, 2010b, 2015, 2016, 2019). If some cities have managed to become greener (particularly in the Northern and Eastern EU), it has been mainly due to urban expansion. These changes also affect shrinking cities, and in every case they trigger negative social and ecological phenomena (European Environment Agency, 2010b; Cortinovis et al., 2019). A comparison of urban spatial development strategies among European cities (Cortinovis et al., 2019) showed that achieving a higher population density in a city only co-occurred with enhancing green space availability in few cases.

Consequently, the incorporation of IGS as temporary green spaces in cities could help to address several issues, e.g. eco-gentrification and social exclusion, hydro-meteorological hazards, quality of life for city dwellers, and urban ecosystem health (Kim, Miller, & Nowak, 2018). This can be an especially important issue in cities in the transitional phase with shrinking and aging populations, resulting in higher numbers of vacant lots and a loss of green areas (Kronenberg, Krauze, & Wagner, 2017). It requires moving away from perceiving those spaces as a spatial and economic burden, and considering them as valuable social and ecological resources in planning processes (Kim, 2018).

If and how people use green spaces depends on their availability, accessibility and attractiveness (Biernacka & Kronenberg, 2018). Direct use is strongly related to residents' perception and how they subjectively assess the area. The benefits of city parks have been explored the most thoroughly (e.g. Bedimo-Rung, Mowen, & Cohen, 2005; Brown, Schebella, & Weber, 2014; Dou, Zhen, De Groot, Du, & Yu, 2017; Langemeyer, Baro, Roebeling, & Gomez-Baggethun, 2015; Rall, Bielin, Zytynska, & Haase, 2017). Studies generally focus on the cultural ecosystem services provided by formal green spaces (see the Appendix A). Work covering citizens' recognition of the regulating services provided by urban parks and greenery is much scarcer (e.g. Bertram & Rehdanz, 2015; Jim & Chen, 2006; see the Appendix A). IGS have been considered even less frequently (e.g. Mathey et al., 2018; Weber, Kowarik, & Saumel, 2014; Table 1, Appendix A). Little is also known about the needs of local residents in terms of redevelopment of IGS (Mathey et al., 2018). As the attractiveness of the space plays an important role in how people consider the value of greenery, the perception of IGS can be highly diverse. They are perceived as problematic areas which are aesthetically undervalued (e.g. unpleasant spaces, perceived as a landfill or a source of social problems) (Brun et al., 2018), untidy and dangerous due to the structure of the vegetation (Jorgensen, Hitchmough, & Dunnett, 2007; Mathey et al., 2018). Conversely, some people see IGS as useful, valuable, highly natural spaces (Brun et al., 2018), characterized by wildness, uniqueness (Pietrzyk-Kaszyńska et al., 2017), biodiversity, and tranquility (Rupprecht et al., 2015).

This paper focuses on IGS in Łódź (central Poland). The aim was to investigate i) the attractiveness and uses of UGS not intended for recreation, ii) the awareness of ecosystem services provided by IGS, iii) conservation vs. redevelopment of IGS, and iv) favorable uses and management of such sites as a basis for planning decisions and policy intervention.

2. Materials and methods

2.1. Study area

Łódź is the third largest city in Poland in terms of population (687,702) and the fourth largest in terms of area (293.25 km^2). Prior to the political and economic changes of 1989, it was a center of the textile industry. Today it is a typical post-industrial city in a transition stage towards new economic and management schemes.

The development of the city took place at the expense of environmental resources. The rapid development initiated in the second half of the 19th century resulted in dense urban development, air, soil and water pollution, and the canalization of watercourses. The economic and social transition initiated in 1989 has led to economic depression (high unemployment, soaring inflation, a significant decrease of GDP) (Kronenberg et al., 2017; Stawasz, 2016), but it also introduced new socio-cultural patterns, which have caused further urbanization and urban sprawl (Kronenberg & Bergier, 2012; Wagner & Breil, 2013). Despite significant improvement after the accession to the European Union, Łódź is still struggling with unemployment (6.3 % in 2017), low GDP per capita (59 347 PLN in 2016) and relatively low average monthly gross wages (4462.50 PLN in 2017, ca 1000 Euro). This indicators classifies Łódź below the national average and averages for Polish towns over 450 thousand inhabitants (PwC, 2015, 2019; Statistical Office in Łódź, 2018; Szukalski, Martinez-Fernandez, & Weyman, 2013). Different stages of the city's development, as well as its economic and political history, have led to negative effects on the wellbeing of its inhabitants, conditioned by environmental goods and environmental risk (Krauze & Włodarczyk-Marciniak, 2018; Kupryś-Lipińska, Kuna, & Wagner, 2014).

In recent years, Łódź has been facing serious demographic challenges such as a rapid shrinking and aging of the population. By 2015, Łódź lost almost 20 % of its population, meanwhile, in other large Polish cities, the process was much less dynamic (Krzysztofik & Szmytkie, 2018). The forecast indicates further decline in population by 2050, resulting in a loss of youth and skilled professionals for the region (Szukalski et al., 2013). It is also experiencing accelerated population aging, in 2017 there were 22.3 % of population aged 65 years and more, and by 2050 it may reach about 37.5 % (Statistical Office in Łódź, 2018). Łódź also struggles with high mortality and morbidity rates, a low fertility rate and low migration attraction (Perek-Białas, Sagan, Stronkowski, & Szukalski, 2017; Szukalski, 2012, 2015). Furthermore, the city is highly divided in terms of place of residence. The central zone is mainly home to low-income and unemployed residents, while the upper and middle classes tend to live outside the old core of the city. This is due to the fact that instead of allocating funds to the reconstruction and revitalization of the pre-war housing stock during the communist period (after the Second World War), efforts were instead focused on building vast residential areas on the outskirts of the city (Marcińczak & Sagan, 2011). This has led to a societal degradation of the city center and to collapse of its physical attributes (Marcińczak & Sagan, 2011). The differences between the city center and its outskirts are also reflected in the health of residents of different zones, e.g. children from the center have a significantly lower body mass and height (Rosset et al., 2012). A similar effect can be noted for the prevalence of asthma in both adults and children, as well as seasonal rhinitis in children (Kupryś & Kuna, 2003; Kupryś-Lipińska, Elgalal, & Kuna, 2009; Kupryś-Lipińska, Elgalal, & Kuna, 2010).

Furthermore, although green spaces cover 61.2 % of the city (Feltynowski et al., 2018), their accessibility is limited, especially in the city center (Kabisch, Strohbach, Haase, & Kronenberg, 2016; Łaszkiewicz et al., 2018; Sikorska, Łaszkiewicz, Krauze, & Sikorski, 2020). According to Sikorska, Łaszkiewicz, Krauze, & Sikorski, 2020, this statistic also includes arable land, private greenery and unmanaged

Table 1
Studies analyzing socio-cultural preferences or perceptions of urban ecosystem services (categories of ecosystem services after Haase et al. (2014)) from IGS (more information in the Appendix A).

Type of informal green space	Category of ecosystem services	Study area	Methodology	Source
multiple informal green spaces	cultural	Melbourne, Australia	interviews	Farahani and Mailer (2019)
home gardens	provisioning, regulating, habitat or supporting, cultural	Nicosia, Cyprus	face-to-face questionnaires	Ciftcioglu and Aydin (2018)
brownfields	provisioning, regulating, cultural	Leipzig, Germany	survey - mapping, public participation GIS	Pueffel et al. (2018)
street trees	regulating, habitat or supporting, cultural	Porto, Portugal	face-to-face questionnaires	Graca et al. (2018)
semi-public grounds; trenches; roadside plantations; house gardens; orchard; natural vegetation;	provisioning, regulating, cultural	Dar es Salaam, Tanzania	participatory appraisal and life history interview	Roy, Shemdoe, Hulme, Mwageni, and Gough (2018)
multiple informal green spaces	regulating, habitat or supporting, cultural	Ichikawa, Japan	mail-back questionnaire	Kim, Rupprecht et al. (2018)
brownfields	cultural	Dresden, Leipzig, Germany	standardized questionnaires	Mathey et al. (2018)
secondary forest	regulating, habitat or supporting, cultural	Singapore	on-site surveys	Hwang and Roscoe (2017)
front garden, grass strip, street tree	regulating, cultural	Rotterdam, Netherlands	face-to-face surveys	Derkzen, van Teeffelen, and Verburg (2017)
multiple informal green spaces	regulating, cultural	Kraków, Łódź, Poznań, Poland	survey - mapping, public participation GIS	Pietrzyk-Kaszyńska et al. (2017)
multiple informal green spaces	provisioning, regulating, habitat or supporting, cultural	Sapporo, Nagano, Kyoto, Kitakyushu, Japan	on-line surveys	Rupprecht (2017)
multiple informal green spaces	provisioning, regulating, habitat or supporting, cultural	Brisbane, Australia; Sapporo, Japan	letterbox-drop, reply-paid mail-back questionnaires	Rupprecht et al. (2015)
roadside vegetation	regulating, habitat or supporting, cultural	Cologne, Berlin, Germany	interviews, standardized questionnaires	Weber et al. (2014)

green spaces, which account for 85.43 % of all vegetated areas. Consequently, only a minority of residents have access to high-quality managed greenery. This especially affects children in Łódź, since only just over 1% of them have good access to parks. According to the same studies, 77 % of those citizens who do not have formal green spaces in their surroundings do have access to IGS. The location of formal green areas in the vicinity of city residents, a high proportion of greenery not being included in urban green space planning and governance, and unequal access to greenery, all make Łódź an important location for analyzing the benefits and management options of IGS ().

2.2. Data collection

An inventory of IGS in the city of Łódź was performed using an orthophoto map (2017) along with the city's vector land use database to exclude formal green areas and define potential sampling plots. Preliminary studies were carried out in 40 IGS. Fenced sites, those with limited access, and those located within housing estates were excluded. In total, five locations were selected for further research (Table 2, Fig. 1). Most of the sites were located in or adjacent to the low income areas of Łódź with a predominance of tenement houses (only the fifth location is outside the degraded area, but the poverty and unemployment rates are similar, the difference is manifested mostly in the predominance of blocks of flats over tenement houses). The majority of inhabitants do not have access to private and community gardens, nor formal green areas of appropriate quality and size with adequate infrastructure in close distance. Two of them represented street greenery (with and without trees, with low levels of maintenance) and three abandoned, derelict sites at different succession phases (with spontaneous pioneer or ruderal vegetation, no maintenance). All sites were selected as the biggest green patches within the neighborhood, and due to proximity of housing.

Data on visitor perception was collected through structured interviews in the immediate vicinity of the selected IGS (see the Appendix B). Since respondents were interviewed on-site (convenience sampling), their replies depended on their familiarity with the area and the direct visual perception of the IGS. The structured, face-to-face interviews were conducted with randomly selected passers-by during two two-hour visits (morning and afternoon) between August and September 2017. The interviews were conducted under similar weather conditions (sunny, above 25 °C). In total, 20 conversations were conducted at each location.

The first part of the questionnaire asked the respondents about their use of IGS (closed-ended questions). The second part explored the respondents' recognition of ecosystem services at the sites, with questions such as "What does the site provide for you?". Respondents could choose from a list of 11 services: five cultural ecosystem services, i.e., looking after their mental health (relaxation), maintaining physical health (recreation), educational use, aesthetic function and inspiration; four regulating services, i.e., air purification, temperature regulation, rainwater retention and noise reduction; provisioning service, i.e., foraging for flowers, fruit and nuts; and supporting services, i.e., habitats for plant and animal species. Finally, the third part asked open-ended questions whether the respondents would like to change anything at the site, and what would it be. The questionnaire also contained a section on socio-demographic data (gender, age, education) (see the Appendix B).

2.3. The interviewees profile

As respondents were randomly selected in the immediate vicinity of the IGS, they did not present equally distributed characteristics. We interviewed 57 women and 43 men (the predominance of women in the group is consistent with the male/female ratio in Łódź). Among them, the majority were young, aged up to 39 (46 people), while 27 respondents were in the middle age (between 40–59) and 27 were elderly

Table 2
Description of the research area.

location	Type	size (m^2)	level of maintenance	percent of tree cover	distance to roads (m)
1	abandoned, ruderal area with varying degrees of succession	2983.66	unmanaged	54.82	0.00
2	street greenery – lawn	857.08	irregularly managed	15.95	0.00
3	street greenery - tree alley	2155.02	irregularly managed	100.00	0.00
4	abandoned, ruderal area with varying degrees of succession	22572.96	unmanaged	27.92	150.00
5	abandoned, ruderal area with varying degrees of succession	16319.19	unmanaged	100.00	120.00

Fig. 1. A map of Łódź with marked research area (left) and the pictures of investigated IGS (right).

(over 60 years old). Just six people had low levels of education, with the majority having attained middle education (56 people). There were 36 people who had completed higher education. Among respondents, the majority were employed (64 people), while 23 respondents were retired, 6 were students and 7 were unemployed.

2.4. Data analysis

We used the chi-square test (Yate's chi-squared test, for a table when at least one cell had an expected count lower than five) to analyze the relationship between the identified ecosystem services and i) variables characterizing green areas (type of IGS and percentage of tree cover) and ii) respondents' socio-demographic characteristics. To determine the strength of the relationship between the variables, contingency coefficients – measures of association – were calculated (Pearson's contingency coefficient C for a 2 × 2 contingency table, and Cramér's V for variables having more than two levels). In order to identify potential co-occurrence of ecosystem services based on the respondents' opinions, we carried out hierarchical cluster analysis (HCA) using the single linkage method with Euclidean distances. We performed a multiple correspondence analysis (MCA, an ordination technique for categorical data) to determine the links between IGS characteristic and any desired design interventions. Statistical analyses were performed using StatSoft Inc., STATISTICA 12.

3. Results

3.1. Identification of ecosystem services

Overall, 98 % of respondents recognized that IGS can provide benefits to society. The most commonly identified services were retention of rainwater (68 %) and providing habitats for plants and animals (68 %). Foraging for flowers, fruit and nuts was the least common (12 %). Among cultural ecosystem services, the aesthetic function was indicated the most (59 %) and inspiration the least frequently (15 %). Our results indicate that respondents were more likely to associate regulating than cultural ecosystem services to IGS (Fig. 2).

Based on the HCA, we distinguished three sets of ecosystem service co-occurrence. The first set contains a high diversity of services,

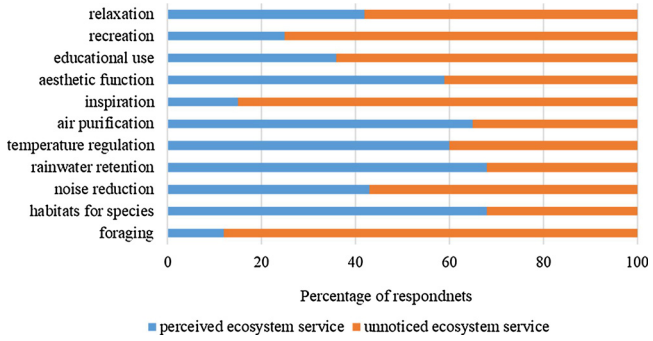

Fig. 2. Perceptions of passers-by regarding the capacity of IGS to provide benefits.

including cultural services (aesthetic function), supporting services (habitat for species) and regulating services (rainwater retention). The second set is mostly dominated by cultural services (recreation, inspiration, educational use), plus one provisioning service (foraging). The third set mainly includes regulating services (temperature regulation, air purification, noise reduction) and one cultural (relaxation) (Fig. 3).

3.2. Factors influencing citizens' awareness of different ES categories

There were significant relationships with weak correlation between interviewee age and their recognition of just three ecosystem services provided by IGS: aesthetic function (Chi2, $p < 0.05$, Cramér's V = 0.263), relaxation (Chi2, $p < 0.05$, Cramér's V = 0.261) and noise reduction (Chi2, $p < 0.05$, Cramér's V = 0.246). Elderly respondents were more likely to associate IGS with the maintenance of good mental health and noise reduction. Aesthetic function was noted more frequently by younger people (Fig. 4). The results also revealed a relationship between higher education and recognition of such services as rainwater retention (Chi^2, $p < 0.05$, Cramér's V = 0.294) and aesthetic function (Chi^2, $p < 0.05$, Cramér's V = 0.336) of IGS (Fig. 5).

The maintenance level of IGS (unmanaged, such as abandoned areas, and irregularly managed, such as street greenery) was related to

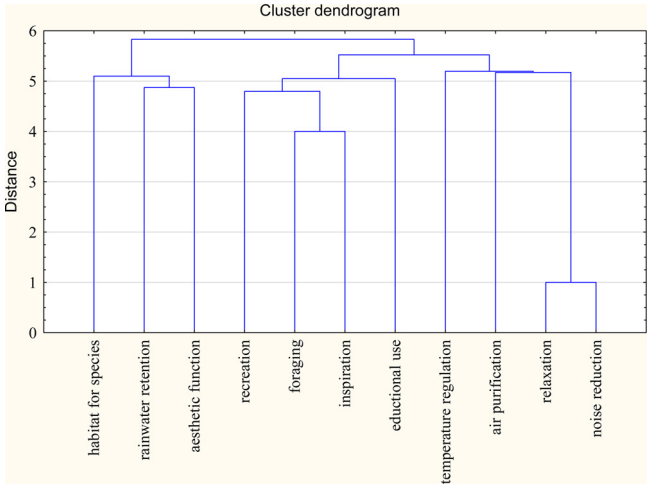

Fig. 3. Dendrogram of the hierarchical cluster analysis. The dendrogram shows ecosystem benefit co-occurrence.

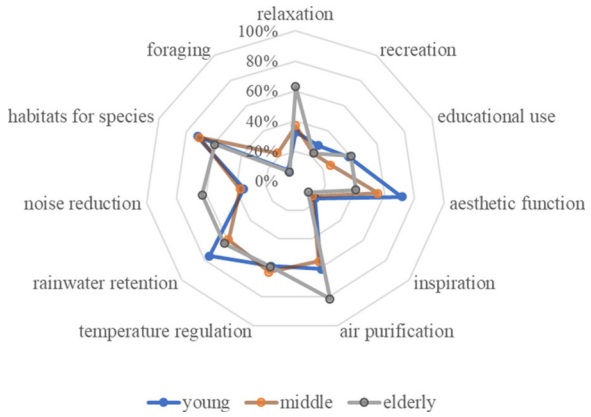

Fig. 4. Perception of the capacity of IGS to provide ecosystem services by age.

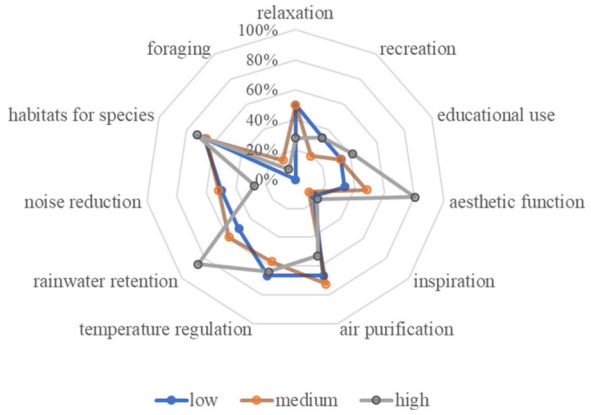

Fig. 5. Perception of the capacity of IGS to provide ecosystem services by education level.

both the aesthetic function (Chi^2, $p < 0.05$, contingency coefficient C = 0.486) and rainwater retention (Chi^2, $p < 0.05$, contingency coefficient C = 0.323) (Fig. 6). The results also revealed a strong correlation between tree coverage and the perception of such ecosystem services as temperature regulation (Chi^2, $p < 0.05$, Cramér's V = 0.460), noise reduction (Chi^2, $p < 0.05$, Cramér's V = 0.309), purification of air (Chi^2, $p < 0.05$, Cramér's V = 0.345) and maintaining good mental health (Chi^2, $p < 0.05$, Cramér's V = 0.318) (Fig. 7)).

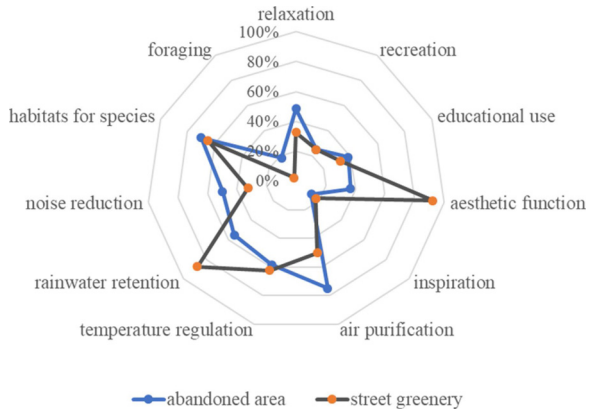

Fig. 6. Perception of the capacity of IGS to provide ecosystem services vs. maintenance level.

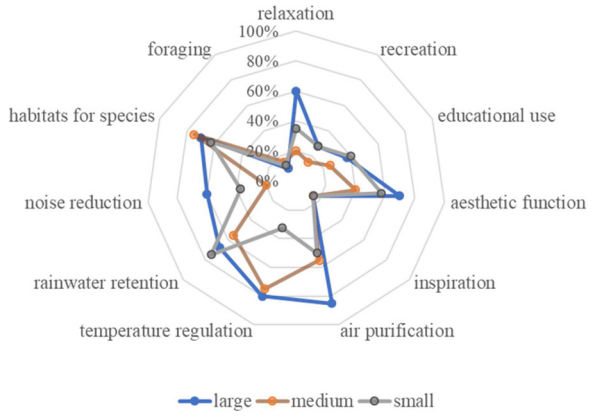

Fig. 7. Perception of the capacity of IGS to provide ecosystem services vs. tree layer area.

3.3. Suggestions for interventions in informal urban green spaces

Almost all respondents (N = 93) expressed a desire to introduce changes to the site under evaluation. Their answers were grouped into six categories:

1 orderliness, including cleaning up the area, mowing herbaceous vegetation (grass, herbs, flowers), and pruning trees;
2 greening measures, such as creating lawns and flowerbeds and tree planting;
3 functionality, such as introducing playgrounds, recreational facilities for sports and games, walking paths and street furniture (benches);
4 elimination and substitution by commercial and service buildings;
5 formalization as a formal green space;
6 security, such as eliminating alcohol consumption.

The descriptive statistics of the categorized suggestions for the design of IGS are included in Table 3. The majority of respondents pointed out a need for orderliness, i.e. increased maintenance (such as mowing herbaceous vegetation and pruning trees) and cleanliness (removing garbage). Improvements to functionality were suggested almost as frequently as orderliness, and included improvements to passive and active rest with benches, playgrounds or outdoor gyms and walking paths. Improvements to the greenery itself were suggested less frequently and included tree planting and beautification, for example with flowerbeds. Improving accessibility to a given area was suggested rarely, as was setting up formal green spaces. Only 2% of respondents suggested building up the area and thus removing the greenery. The

Table 3
Suggested changes to the management of IGS (responses in %). Categories do not add up to 100 %, as respondents could give more than one answer.

Low-scale design intervention	Coding (n = 93) %
Orderliness	60
mowing herbaceous vegetation (grass, herbs, flowers)	*42*
pruning trees	*29*
cleaning up the area	*14*
Functionality	57
street furniture (benches)	*47*
playgrounds	*14*
walking paths	*10*
recreational facilities for sports and games	*9*
Greening measures	41
flowerbeds	*25*
tree planting	*23*
neat lawns	*4*
Formalization	13
creation of formal green spaces	*13*
Security	12
elimination of alcohol consumption	*12*
Elimination	2
commercial and service buildings	*2*

majority of respondents pointed out an absence of alternative green areas in their neighborhoods, which would allow them to relax on hot days, play with their children or walk their dog.

The first two axes of the MCA accounted for 33.18 % of the inertia (Fig. 8). The first axis (20.81 % of inertia) divided IGS redevelopment suggestions into unmanaged, large IGS at far from roads, and irregularly managed, small IGS close to roads. The second axis (12.37 % of inertia) mainly relates to the division due to tree coverage. Benches, playgrounds, recreational facilities for elderly people and walking paths were mainly suggested for unmanaged, large IGS far from roads. Pruning trees, eliminating alcohol consumption and cleaning up the area were mainly suggested for IGS with large tree coverage. Greening measures, such as creating flowerbeds, planting trees and maintaining neat lawns, were suggested for irregularly managed, small IGS far from roads. Planting trees was also more frequently suggested for IGS with small tree coverage.

4. Discussion

In general, this study reveals that (i) residents perceive IGS as places able to provide a range of services, mainly regulating services, (ii) even low-scale design interventions can improve the attractiveness of IGS, and (iii) IGS are regarded as important vegetated areas in the city which can be complementary to formal greenery.

Fig. 8. Multiple correspondence analysis (MCA) of IGS characteristics and respondents' ideas/perceptions. Variables marked with rectangles represent the characteristic of the analyzed IGS, and the grey variables represent design interventions.

4.1. Awareness of ecosystem services

The results show that Łódź residents do associate IGS with ecosystem services, in particular with habitat provision for wildlife, rainwater retention, air purification, local temperature regulation and aesthetic function. This is consistent with the findings of previous studies, showing that citizens recognize that IGS provide a number of benefits (Kim, Rupprecht, & Furuya, 2018; Rupprecht, 2017). Some studies suggest that cultural and provisioning services are identified more easily than regulating and supporting ones, since they are experienced directly (Andersson, Tengö, McPhearson, & Kremer, 2015; Brown, Montag, & Lyon, 2012; Daniel et al., 2012; Pueffel, Haase, & Priess, 2018), while services not experienced directly may be undervalued or not recognized at all (Scholte, van Teeffelen, & Verburg, 2015). Our study confirms the results reported by Graca, Queiros, Farinha-Marques, and Cunha (2018), Kim, Rupprecht et al. (2018), Pietrzyk-Kaszyńska et al. (2017) and Rupprecht (2017), showing that people are aware of IGS as providers of habitats and regulating services, and that environmental functions of IGS are predominant in community awareness.

Although many research results show that IGS are able to efficiently fill a gap in the availability of urban, green recreational spaces (Mathey, Rößler, Banse, Lehmann, & Bräuer, 2015; Pietrzyk-Kaszyńska et al., 2017; Rupprecht & Byrne, 2014b; Rupprecht, 2017), in our case the majority of users treated IGS as shortcuts rather than destination points (e.g. dog walking); this may have been due to constraints discussed further in the paper.

Despite a global increase in interest in urban agriculture and foraging for fruit/plants, our respondents did not consider wild plant harvesting (flowers, nuts, fruit) in IGS in Łódź. It should be noted that our results do not indicate levels of foraging; they simply show that just 12 % of respondents admitted that IGS could be used for urban foraging. This may reflect concerns about whether urban plants are suitable for eating (Russo, Escobedo, Cirella, & Zerbe, 2017), e.g. due to metal contamination (e.g. Antisari, Orsini, Marchetti, Vianello, & Gianquinto, 2015; Säumel et al., 2012). This bias is unfortunate because urban foraging could be an important and widely accessible way of handling environmentally-friendly production and transport of food, and tackling social issues such as poverty (Landor-Yamagata, Kowarik, & Fischer, 2018; Russo et al., 2017; Shackleton, Hurley, Dahlberg, Emery, & Nagendra, 2017). More information may be needed on the subject, including issues favoring the development of IGS which may provide food provisioning, for example by introducing natural barriers to pollution (e.g. planting trees along the street (Al-Dabbous & Kumar, 2014)).

In line with previous studies (Kim, Rupprecht et al., 2018; Rupprecht, 2017), IGS are recognized by residents as important wildlife refuges. Additionally, studies focused directly on analyzing species diversity at sites with spontaneous vegetation confirm this belief (Bonthoux et al., 2014). Rarely mown or never mown IGS, which are frequently found in cities, support flora and fauna which otherwise would not have a chance to flourish (Threlfall & Kendal, 2018). Respondents recognizing IGS as valuable habitats for species may indicate their general environmental awareness.

Most studies attempting to link socio-demographic factors with people recognizing or valuing the benefits of IGS show no (Kim, Rupprecht et al., 2018) or a limited (Graca et al., 2018; Rupprecht et al., 2015) relationship. In our study, respondents showed a high awareness of ecosystem services of IGS; this is related not only to their age or education, but also to the features of the site (e.g. tree coverage, management level). However, socio-demographic factors appear to be statistically related with just three UES: aesthetic function, mental

health benefits and noise reduction. The aesthetic function of IGS was more highly recognized by younger and highly educated people. Elderly respondents were more likely to recognize the positive influence of IGS on mental health and noise reduction. This could be related to generational variance and age-related needs, which is linked with a higher physical and mental vulnerability of the elderly. The findings are concordant with those by Van den Berg and van Winsum-Westra (2010) and Van den Berg and Koole (2006), where people with an academic education rated wild spaces as more beautiful, and elderly people displayed relatively high preferences for managed natural settings. Contrary to the findings of Graca et al. (2018), we did not find gender-related differences in attitudes towards IGS.

Additionally, our research shows that street greenery makes cities more attractive. We speculate that this may be due to the fact that, unlike other locations, these areas are minimally managed by the city authorities (perhaps mown a few times a year), which is more often perceived as attractive (Özünger & Kendle, 2006). Additionally, street greenery protects against pluvial flooding (through retention of rainwater), which is a highly recognized problem in densely built-up city centers during rain events (Wagner & Zalewski, 2009). The answers indicated that the presence of trees on land parcels is particularly associated with noise reduction, temperature regulation and air purification, which may be due to the responders' beliefs/feelings or the increasing availability and accessibility of scientific evidence. The findings are directly in line with research which provides evidence that urban trees reduce heat stress (Bowler, Buyung-Ali, Knight, & Pullin, 2010), noise levels (Nowak & Dwyer, 2007) and air pollutants (Escobedo, Kroeger, & Wagner, 2011; Nowak & Dwyer, 2007; Nowak, Hirabayashi, Bodine, & Greenfield, 2014). Furthermore, the presence of trees is related to respondents recognizing mental health benefits of IGS, which confirms findings of other studies (Gerstenberg & Hofmann, 2016). Additionally, species diversity is sometimes linked with a positive influence on the mental health of urban dwellers (Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007).

4.2. Suggestions for design interventions

Due to various constraints and barriers, such as lack of accessibility, limited local knowledge or acceptance, the cultural services of IGS, especially those related to recreation, are not fully exploited (Mathey et al., 2015). A similar conclusion was reached by our study, where people did not use these spaces for recreation and did not attribute them with educational and inspirational values. Since in many cities only cultural benefits make the presence of greenery formally recognized in decision-making processes, and thus protected under local plans, we consider suggestions for bringing these these benefits to analyzed areas to be particularly valuable.

The most common suggestion from our respondents was to improve the orderliness of IGS, e.g. through better maintenance and tidying, to make them more inviting. This is in line with other studies showing a preference for manicured, neat and well-kept UGS (Özünger & Kendle, 2006) and an increased use of IGS, such as brownfields, if those were at least minimally maintained (Farahani & Mailer, 2019; Hofmann, Westermann, Kowarik, & van der Meer, 2012; Mathey et al., 2015). This preference for managed greenery rather than a more natural, wilder appearance was also emphasized in previous studies (Hands & Brown, 2002; Hofmann et al., 2012; Jorgensen et al., 2007; Lafortezza, Corry, Sanesi, & Brown, 2008; Rink & Arndt, 2016). Another suggested change, almost as popular as improved orderliness, was to improve the functionality of IGS, for example by adding benches or delineation of walking paths; this is concordant with results obtained by Unt and Bell (2014), who showed that the number of users increased when a few pieces of equipment were set in an urban wilderness. The demand for green measures was less popular. The preference for new greenery was largely in line with the provision of manicured space, by indicating flowerbeds and neat lawns. A preference for such tidy formal features was also found in other studies (Özünger & Kendle, 2006; Poškus & Poškienė, 2015; Sikorski et al., 2018); additionally, it was shown that the presence of flowers clearly increases the attractiveness of UGS in many cases (e.g. Lee, Williams, Sargent, Farrell, & Williams, 2014; Lindemann-Matthies & Brieger, 2016; Todorova, Asakawa, & Aikoh, 2004). Passers-by also expressed a desire for more trees to be planted in IGS. Similarly, other studies have shown a fondness for urban trees among citizens (Camacho-Cervantes, Schondube, Castillo, & MacGregor-Fors, 2014; Fernandes, DaSilva, Teixeira, & Costa, 2019; Lafortezza et al., 2008; Todorova et al., 2004).

Some respondents stated that they consider IGS to be unsafe. This was mainly due to littering, overgrown greenery and people consuming alcohol. As a result, they proposed solutions that would improve the safety of the site, which did not always include removing greenery and changing its wild appearance. Instead, they suggested for example, frequent inspections by city authorities or municipal police. The problem of perceived safety risks in IGS is widespread and recognized in literature (Jorgensen et al., 2007; Özünger & Kendle, 2006; Rink & Arndt, 2016). The reasons given include dense, unmanaged vegetation, which translates into short viewing distances (Bixler & Floyd, 1997; Schroeder & Anderson, 1983), where vegetation interferes with surveillance (Jorgensen, Hitchmough, & Calvert, 2002). This can be conducive to antisocial behavior such as dumping rubbish, violence, harassment and drug/alcohol consumption (Rall & Haase, 2011; Rink & Arndt, 2016). Several studies suggest that even minor maintenance interventions such as trimming vegetation (Rall & Haase, 2011; Unt & Bell, 2014) can reduce the perception of danger (Lindemann-Matthies & Brieger, 2016; Özünger & Kendle, 2006).

Our results make it clear, however, that suggestions for design interventions are highly dependent on the type of IGS, in particular its size, closeness to roads, tree coverage and type of management. In particular, unmanaged, large IGS located far from roads are frequently linked with a need to improve their functionality, safety and orderliness. The presence of trees increases the emphasis on tree-focused activities, such as pruning or planting, and on safety and clean-up issues.

Some respondents also suggested formalizing IGS and integrating them into the city's existing system of green infrastructure, which could be beneficial to the long-term preservation of ecosystem services. These idea is well-known and described in the literature (Brun et al., 2018; Kremer & Hamstead, 2015; Mathey et al., 2018).

4.3. Justifications for sustaining IGS in cities

Scarce greenery in city centers is significantly linked with a decreased life expectancy (e.g. Jonker, van Lenthe, Donkers, Mackenbach, & Burdorf, 2014; Takano, Nakamura, & Watanabe, 2002), increased morbidity (Maas et al., 2009), greater risk of allergies (Alcock et al., 2014; Ruokolainen, Fyhrquist, & Haahtela, 2016), cardiovascular and respiratory disease (Donovan et al., 2013) and higher obesity rates (Villeneuve, Jerrett, Su, Weichenthal, & Sandler, 2018). Contact with nature is known to influence mental health through lowering depression (Sarkar, Webster, & Gallacher, 2018), anxiety (Gascon et al., 2018) and stress (Pun, Manjourides, & Suh, 2018; Tyrväinen et al., 2014), improving concentration (Ottosson & Grahn, 2006), and reducing aggressive and violent behavior (Younan et al., 2016). There are also a number of indirect effects of green infrastructure on wellbeing, emerging from regulating ecosystem services. Greenery in cities can help to cool the environment through evapotranspiration and shade provision (Bowler et al., 2010; Djekić et al., 2018; Kleerekoper, van Esch, & Salcedo, 2012), reduce noise nuisance (Dzhambov & Dimitrova, 2015; Li, Chau, & Tang, 2010; Van Renterghem & Botteldooren, 2016), and filter particulate matter from polluted air (Popek, Gawrońska, Sæbø, Wrochna, & Gawroński, 2013; Przybysz, Nersisyan, & Gawroński, 2019). Almost 84.5 % of Łódź residents have highly limited access to any formal UGS. This has a twofold effect: it places existing high-quality green areas at risk of invasion of housing estates, and increases the

effects of eco-gentrification, making the most vulnerable communities more exposed to adverse effects of urbanization and climate change (Anguelovski, Connolly, Masip, & Pearsall, 2018; Koprowska, Łaszkiewicz, & Kronenberg, 2020; Pearsall & Eller, 2020; Rigolon & Nemeth, 2020; Wolch, Byrne, & Newell, 2014). In both cases, IGS can serve as important planning alternatives, especially in cities where they are as abundant and widespread as in Łódź (Sikorska, Łaszkiewicz, Krauze, & Sikorski, 2020). Their integration into spatial planning systems as new temporary or permanent green spaces can be a viable solution, potentially welcome by residents, who – as shown by our research – are aware of the impact such places have on their quality of life. Since cultural ecosystem services are co-created by people and ecosystems (Andersson et al., 2015), this is likely to set IGS in the city fabric by activities that promote their widespread use. A similar pattern of results was obtained by Mathey et al. (2018): their research into urban brownfields with spontaneous vegetation shows that in the case of redevelopment, spontaneous vegetation should be linked with aesthetic motives as well as traditional concepts of land management in order to meet the residents' preferences for land use. This can lead to higher acceptance by local residents and help spatial planners to combine nature conservation and use of greenery (Mathey et al., 2018; Sukopp, 2005). Moreover, the changes requested by respondents in our research referred to relatively minor interventions that would not always completely change the nature of the site nor impose a burden on municipal services. Such balanced intervention can meet the requirements of both people and nature. Additionally, the suggestion to plant trees in places with scarce tall vegetation would improve biodiversity and regulatory services. Indeed, studies of the influence of revitalization of brownfields conducted by Koch, Bilke, Helbig, and Schlink (2018) show that redevelopment does not always lead to a reduction of i.e. cooling effects.

IGS can become areas which provide city residents access to greenery, improving their quality of life. Excluding them from development plans can be a critical element of environmental justice. Every aspect of intervention in urban areas takes into account their morphology as well as function and connectivity, and should be considered in a comprehensive way as a socio-ecological approach to transitions towards city sustainability (Krauze & Wagner, 2019; Kronenberg et al., 2017). In the Łódź example the majority of the respondents were in favour of preserving IGS after only minor interventions. Thus expectations were very modest and could be met at very low cost to the city. The claim raised as a response to the absence of alternative green areas in neighborhoods, and lack of other alternatives (private green spaces, opportunities to move out, or spend time outside the city). Consequently considering IGS in local plans would significantly improve living conditions of interviewed commuters, while simultaneously the interventions (cleaning, creating walking paths, benches) would have broader positive effect e.g. on vulnerable communities (elderly, children, poor). In the conditions of generally poor health status of citizens, exacerbated by effects of climate change, shrinking and aging population, and struggle with poverty and social exclusion, IGS seem to be the easiest, and the most economical way to create multiple benefits to society and nature-based insurance system. Lack of formal recognition of IGS creates a very fragile balance between green and grey infrastructure, questioning sustainability and adaptability of cities. During preparation of this paper two out of five studied areas have been already lost for housing development. It coincided with coronavirus outbreak followed by enclosure of all formal green areas (still located at half kilometers distance, and separated with barriers – busy streets and railways from study places). The situation became an eye opening event to residents of many city districts, whose daily activities got squeezed to tiny, overcrowded back and front yards. There is however no evidence of changes in the city spatial planning policy while many other European cities started to revise approach to IGS (Samuelsson, Barthel, Colding, Macassa, & Giusti, 2020).

5. Conclusions

- IGS in the Polish city of Łódź are perceived by residents as places able to provide a range of ecosystem services, especially those responsible for regulating ecosystem processes.
- These spaces are not used to their full potential at present; however, local residents have made suggestions for minor design interventions which should change this.
- The majority of suggestions indicate a desire for improving the attractiveness of IGS.
- IGS are important vegetated areas in the city which should be protected from being built on to complement formal green spaces in Łódź.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was carried out as part of the project ENABLE, funded through the 2015–2016 BiodivERsA COFUND call for research proposals, with the national funders The Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning, Swedish Environmental Protection Agency, German Aeronautics and Space Research Centre, National Science Centre (Poland – grant no. 2016/22/Z/NZ8/00003), The Research Council of Norway and the Spanish Ministry of Economy and Competitiveness.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.scs.2020.102236.

References

Alcock, I., White, M. P., Wheeler, B. W., Fleming, L. F., & Depledge, M. H. (2014). Longitudinal effects on mental health of moving to greener and less green urban areas. *Environmental Science & Technology, 48*(2), 1247–1255.

Al-Dabbous, N., & Kumar, P. (2014). The influence of roadside vegetation barriers on airborne nanoparticles and pedestrians exposure under varying wind condition. *Atmospheric Environment, 90*, 113–124.

Andersson, E., Tengö, M., McPhearson, T., & Kremer, P. (2015). Cultural ecosystem services as a gateway for improving urban sustainability. *Ecosystem Services, 12*, 165–168.

Anguelovski, I., Connolly, J. J. T., Masip, L., & Pearsall, H. (2018). Assessing green gentrification in historically disenfranchised neighborhoods: A longitudinal and spatial analysis of Barcelona. *Urban Geography, 39*(3), 458–491.

Antisari, L. V., Orsini, F., Marchetti, L., Vianello, G., & Gianquinto, G. (2015). Heavy metal accumulation in vegetables grown in urban gardens. *Agronomy for Sustainable Development, 35*, 1139–1147.

Battisti, L., Pille, L., Wachtel, T., Larcher, F., & Säumel, I. (2019). Residential greenery: State of the art and health-related ecosystem services and disservices in the city of Berlin. *Sustainability, 11*, 1815.

Bedimo-Rung, A. L., Mowen, A. J., & Cohen, D. A. (2005). The significance of parks to physical activity and public health: A conceptual model. *American Journal of Preventive Medicine, 28*(2), 159–168.

Bertram, C., & Rehdanz, K. (2015). Preferences for cultural urban ecosystem services: Comparing attitudes, perception, and use. *Ecosystem Services, 12*, 187–199.

Biernacka, M., & Kronenberg, J. (2018). Classification of institutional barriers affecting the availability, accessibility and attractiveness of urban green spaces. *Urban Forestry & Urban Greening, 36*, 22–33.

Bixler, R., & Floyd, M. (1997). Nature is scaring, disgusting, and uncomfortable. *Environment and Behavior, 28*(4), 443–467.

Bonthoux, S., Brun, M., Di Pietro, F., Greulich, S., & Bouché-Pillon, S. (2014). How can wastelands promote biodiversity in cities? A review. *Landscape and Urban Planning, 132*, 79–88.

Bowler, D. E., Buyung-Ali, L., Knight, T. M., & Pullin, A. S. (2010). Urban greening to cool towns and cities: A systematic review of the empirical evidence. *Landscape and Urban Planning, 97*, 147–155.

Brown, G., Montag, J. M., & Lyon, K. (2012). Public participation GIS: A method for identifying ecosystem services. *Society & Natural Resources: An International Journal,*

25(7), 633–651.
Brown, G., Schebella, M. F., & Weber, D. (2014). Using participatory GIS to measure physical activity and urban park benefits. *Landscape and Urban Planning, 121*, 34–44.
Brun, M., Di Pietro, F., & Bonthoux, S. (2018). Residents' perceptions and valuations of urban wastelands are influenced by vegetation structure. *Urban Forestry & Urban Greening, 29*, 393–403.
Camacho-Cervantes, M., Schondube, J. E., Castillo, A., & MacGregor-Fors, I. (2014). How do people perceive urban trees? Assessing likes and dislikes in relation to the trees of a city. *Urban Ecosystems, 17*(3), 761–773.
Ciftcioglu, G. C., & Aydin, A. (2018). Urban ecosystem services delivered by green open spaces: An example from Nicosia City in North Cyprus. *Environmental Monitoring and Assessment, 190*(10), 613.
Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). *Nature-based Solutions to address global societal challenges.* Gland, Switzerland: IUCN.
Cortinovis, C., Haase, D., Zanon, B., & Geneletti, D. (2019). Is urban spatial development on the right track? Comparing strategies and trends in the European Union. *Landscape and Urban Planning, 181*, 22–37.
Daniel, T. C., Muhar, A., Arnberger, A., Aznar, O., Boyd, J. W., Chan, K. M. A., et al. (2012). Contributions of cultural services to the ecosystem services agenda. *Proceedings of the National Academy of Sciences of the United States of America, 109*(23), 8812–8819.
Depietri, Y., Renaud, F. G., & Kallis, G. (2012). Heat waves and floods in urban areas: A policy-oriented review of ecosystem services. *Sustainability Science, 7*, 95–107.
Derkzen, M. L., van Teeffelen, A. J. A., & Verburg, P. H. (2017). Green infrastructure for urban climate adaptation: How do residents' views on climate impacts and green infrastructure shape adaptation preferences? *Landscape and Urban Planning, 157*, 106–130.
Djekić, J. P., Mitković, P. B., Dinić Branković, M. M., Igić, M. Z., Djekić, P. S., & Mitković, M. P. (2018). The study of effects of greenery on temperature reduction in urban areas. *Thermal Science, 22*(4), 989–1000.
Donovan, G. H., Butry, D. T., Michael, Y. L., Prestemon, J. P., Liebhold, A. M., Gatziolis, D., et al. (2013). The relationship between trees and human health: Evidence from the spread of the emerald ash borer. *American Journal of Preventive Medicine, 44*(2), 139–145.
Dou, Y., Zhen, L., De Groot, R., Du, B., & Yu, X. (2017). Assessing the importance of cultural ecosystem services in urban areas of Beijing municipality. *Ecosystem Services, 24*, 79–90.
Dzhambov, A. M., & Dimitrova, D. D. (2015). Green spaces and environmental noise perception. *Urban Forestry & Urban Greening, 14*, 1000–1008.
Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: Analyzing ecosystem services and disservices. *Environmental Pollution, 159*, 2078–2087.
European Commission (2015). *Horizon 2020 towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities. Final report of the horizon 2020 expert group*Luxembourg: European Union.
European Environment Agency (2009). *Ensuring quality of life in Europe's cities and towns, EEA Report No 5/2009*Copenhagen, Denmark: European Environment Agency.
European Environment Agency (2012). *Urban adaptation to climate change in Europe, EEA Report No 2/2012*Copenhagen, Denmark: European Environment Agency.
European Environment Agency (2015). *The European environment — State and outlook 2015, synthesis report*Copenhagen, Denmark: European Environment Agency.
European Environment Agency (2016). *Land recycling in Europe. Approaches to measuring extent and impacts, EEA report No 31/2016*Copenhagen, Denmark: European Environment Agency.
European Environment Agency (2019). *The European environment – State and outlook 2020. Knowledge for transition to a sustainable Europe.* Copenhagen, Denmark: European Environment Agency.
European Environment Agency (2010a). *The European environment — State and outlook 2010: Urban environment.* Copenhagen, Denmark: European Environment Agency.
European Environment Agency (2010b). *10 messages for 2010 — Urban ecosystems.* Copenhagen, Denmark: European Environment Agency.
European Environment Agency & Joint Research Centre (2013). *Environment and human health, EEA report No 5/2013.* European Environment Agency and the European Commission's Joint Research Centre.
Farahani, L. M., & Mailer, C. (2019). Investigating the benefits of' leftover' places: Residents' use and perceptions of an informal greenspace in Melbourne. *Urban Forestry & Urban Greening, 41*, 292–302.
Feltynowski, M., Kronenberg, J., Bergier, T., Kabisch, N., Łaszkiewicz, E., & Stohbach, M. W. (2018). Challenges of urban green space management in the face of using inadequate data. *Urban Forestry & Urban Greening, 31*, 56–66.
Fernandes, C. O., DaSilva, I. M., Teixeira, C. P., & Costa, L. (2019). Between tree lovers and tree haters: Drivers of public perception regarding street trees and its implications on the urban green infrastructure planning. *Urban Forestry & Urban Greening, 37*, 97–108.
Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H., & Gaston, K. J. (2007). Psychological benefits of greenspace increase with biodiversity. *Biology Letters, 3*, 390–394.
Gascon, M., Sánchez-Benavides, G., Dadvand, P., Martínez, D., Gramunt, N., Gotsens, X., et al. (2018). Long-term exposure to residential green and blue spaces and anxiety and depression in adults: A cross-sectional study. *Environmental Research, 162*, 231–239.
Gerstenberg, T., & Hofmann, M. (2016). Perception and preference of trees: A psychological contribution to tree species selection in urban areas. *Urban Forestry & Urban Greening, 15*, 103–111.
Graca, M., Queiros, C., Farinha-Marques, P., & Cunha, M. (2018). Street trees as cultural elements in the city: Understanding how perception affects ecosystem services management in Porto, Portugal. *Urban Forestry & Urban Greening, 30*, 194–205.
Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., et al. (2008). Global change and the ecology of cities. *Science, 319*, 756–760.
Haase, Dagmar, Larondelle, Neele, Andersson, Erik, Artmann, Martina, Borgström, Sara, ... Breuste, Jürgen, et al. (2014). A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, Models, and Implementation. *AMBIO, 43*, 413–433. https://doi.org/10.1007/s13280-014-0504-0.
Hands, D. E., & Brown, R. D. (2002). Enhancing visual preference of ecological rehabilitation sites. *Landscape and Urban Planning, 58*, 57–70.
Hofmann, M., Westermann, J. R., Kowarik, I., & van der Meer, E. (2012). Perceptions of parks and urban derelict land by landscape planners and residents. *Urban Forestry & Urban Greening, 11*, 303–312.
Hwang, Y. H., & Roscoe, C. J. (2017). Preference for site conservation in relation to on-site biodiversity and perceived site attributes: An on-site survey of unmanaged urban greenery in a tropical city. *Urban Forestry & Urban Greening, 28*, 12–20.
Jim, C. Y., & Chen, W. Y. (2006). Perception and attitude of residents toward urban green spaces in Guangzhou (China). *Environmental Management, 38*(3), 338–349.
Jonker, M. F., van Lenthe, F. J., Donkers, B., Mackenbach, J. P., & Burdorf, A. (2014). The effect of urban green on small-area (healthy) life expectancy. *Journal of Epidemiology and Community Health, 68*(10), 999–1002.
Jorgensen, A., Hitchmough, J., & Dunnett, N. (2007). Woodland as a setting for housing-appreciation and fear and the contribution to residential satisfaction and place identity in Warrington New Town, UK. *Landscape and Urban Planning, 79*, 273–287.
Jorgensen, A., Hitchmough, J., & Calvert, T. (2002). Woodland spaces and edges: Their impact on perception of safety and preference. *Landscape and Urban Planning, 60*, 135–150.
Kabisch, N., Strohbach, M., Haase, D., & Kronenberg, J. (2016). Urban green space availability in European cities. *Ecological Indicators, 70*, 586–596.
Kim, G. (2018). An integrated system of urban green infrastructure on different types of vacant land to provide multiple benefits for local communities. *Sustainable Cities and Society, 36*, 116–130.
Kim, G., & Miller, P. A. (2019). The impact of green infrastructure on human health and well-being: The example of the Huckleberry Trail and the Heritage Community Park and Natural Area in Blacksburg, Virginia. *Sustainable Cities and Society, 48*, 101562.
Kim, G., Miller, P. A., & Nowak, D. J. (2018). Urban vacant land typology: A tool for managing urban vacant land. *Sustainable Cities and Society, 36*, 144–156.
Kim, M., Rupprecht, C. D. D., & Furuya, K. (2018). Residents' perception of informal green space. A case study of Ichikawa City, Japan. *Land, 7*(3), 102.
Kleerekoper, L., van Esch, M., & Salcedo, T. B. (2012). How to make a city climate-proof, addressing the urban heat island effect. *Resources, Conservation, and Recycling, 64*, 30–38.
Koch, F., Bilke, L., Helbig, C., & Schlink, U. (2018). Compact or cool? The impact of brownfield redevelopment on inner-city micro climate. *Sustainable Cities and Society, 38*, 31–41.
Koprowska, K., Łaszkiewicz, E., & Kronenberg, J. (2020). Is urban sprawl linked to green space availability? *Ecological Indicators, 108*, 105723.
Kowarik, I. (2013). Cities and wilderness. A new perspective. *International Journal of Wilderness, 19*(3), 32–36.
Krauze, K., & Wagner, I. (2019). From classical water-ecosystem theories to nature-based solutions—Contextualizing nature-based solutions for sustainable city. *The Science of the Total Environment, 655*, 697–706.
Krauze, K., & Włodarczyk-Marciniak, R. (2018). Defining the risk to water and natural capital in cities with risk component analysis tool (DAPSET): Case study Łódź. *Journal of Environmental Management, 227*, 62–72.
Kremer, P., & Hamstead, Z. (2015). Transformation of urban vacant lots for the common good: An introduction to the special issue. *Cities and the Environment (CATE), 8*, 1.
Kremer, P., Hamstead, Z. A., & McPhearson, T. (2013). A social-ecological assessment of vacant lots in New York City. *Landscape and Urban Planning, 120*, 218–233.
Kronenberg, J. (2015). Why not to green a city? Institutional barriers to preserving urban ecosystem services. *Ecosystem Services, 12*, 218–227.
Kronenberg, J., & Bergier, T. (2012). Sustainable development in a transition economy: Business case studies from Poland. *Journal of Cleaner Production, 26*, 18–27.
Kronenberg, J., Krauze, K., & Wagner, I. (2017). Focusing on ecosystem services in the multiple social-ecological transitions of Lodz. In N. Frantzeskaki, V. C. Broto, L. Coenen, & D. Loorbach (Eds.). *Urban sustainability transitions* (pp. 331–345). London: Routledge.
Krzysztofik, R., & Szmytkie, R. (2018). Depopulation in Poland in the light of changes in city functions. *Przegląd Geograficzny, 90*(2), 309–329.
Kupryś, I., & Kuna, P. (2003). Epidemics of allergic diseases: A new health problem in the modern world. *Polski Merkuriusz Lekarski, 14*(83), 453–455.
Kupryś-Lipińska, I., Elgalal, A., & Kuna, P. (2009). Urban-rural differences in the prevalence of atopic diseases in the general population in Lodz Province (Poland). *Postępy Dermatologii i Alergologii, 26*(5), 249–256.
Kupryś-Lipińska, I., Elgalal, A., & Kuna, P. (2010). The underdiagnosis and undertreatment of asthma in general population of the Lodz Province (Poland). *Pneumonologia i Alergologia Polska, 78*(1), 21–27.
Kupryś-Lipińska, I., Kuna, P., & Wagner, I. (2014). Water in the urban space and health of residents. In T. Bergier, J. Kronenberg, & I. Wagner (Eds.). *Water in the city. Sustainable development applications series 5* (pp. 47–55). Kraków: Sendzimir Fundation.
Lafortezza, R., Corry, R. C., Sanesi, G., & Brown, R. D. (2008). Visual preference and ecological assessments for designed alternative brownfield rehabilitations. *Journal of Environmental Management, 89*, 257–269.
Landor-Yamagata, J. L., Kowarik, I., & Fischer, L. K. (2018). Urban foraging in Berlin: People, plants and practices within the metropolitan green infrastructure. *Sustainability, 10*, 1873.

Langemeyer, J., Baro, F., Roebeling, P., & Gomez-Baggethun, E. (2015). Contrasting values of cultural ecosystem services in urban areas: The case of park Montjuïc in Barcelona. *Ecosystem Services, 12*, 178–186.

Łaszkiewicz, E., Kronenberg, J., & Marcińczak, S. (2018). Attached to or bound to a place? The impact of green space availability on residential duration: The environmental justice perspective. *Ecosystem Services, 30*, 309–317.

Lee, K. E., Williams, K. J. H., Sargent, L. D., Farrell, C., & Williams, N. S. (2014). Living roof preference is influenced by plant characteristics and diversity. *Landscape and Urban Planning, 122*, 152–159.

Li, H. N., Chau, C. K., & Tang, S. K. (2010). Can surrounding greenery reduce noise annoyance at home? *The Science of the Total Environment, 408*, 4376–4384.

Lindemann-Matthies, P., & Brieger, H. (2016). Does urban gardening increase aesthetic quality of urban areas? A case study from Germany. *Urban Forestry & Urban Greening, 17*, 33–41.

Liu, W., Chen, W., & Peng, C. (2014). Assessing the effectiveness of green infrastructures on urban flooding reduction: A community scale study. *Ecological Modelling, 291*, 6–14.

Maas, J., Verheij, R. A., de Vries, S., Spreeuwenberg, P., Schellevis, F. G., & Groenewegen, P. P. (2009). Morbidity is related to a green living environment. *Journal of Epidemiology and Community Health, 63*, 967–973.

Marcińczak, S., & Sagan, I. (2011). The socio-spatial restructuring of Łódź, Poland. *Urban Studies, 48*(9), 1789–1809.

Mathey, J., Arndy, T., Banse, J., & Rink, D. (2018). Public perception of spontaneous vegetation on brownfields in urbanareas—Results from surveys in Dresden and Leipzig (Germany). *Urban Forestry & Urban Greening, 29*, 384–392.

Mathey, J., Rößler, S., Banse, J., Lehmann, I., & Bräuer, A. (2015). Brownfields as an element of green infrastructure for implementing ecosystem services into urban areas. *Journal of Urban Planning and Development, 141*(3) A4015001-1–A4015001-13.

Millennium Ecosystem Assessment (2005). *Ecosystems and human well-being: Synthesis.* Washington, DC: World Resources Institute. Island Press.

Nordh, H., Evensen, K. H., & Skar, M. (2017). A peaceful place in the city-A qualitative study of restorative components of the cemetery. *Landscape and Urban Planning, 167*, 108–111.

Nowak, D. J., & Dwyer, J. F. (2007). Understanding the benefits and costs of urban forest ecosystems. In J. E. Kuser (Ed.). *Urban and community forestry in the Northeast* (pp. 25–62). (2nd ed.). New York: Springer.

Nowak, D. J., Hirabayashi, S., Bodine, A., & Greenfield, E. (2014). Tree and forest effects on air quality and human health in the United States. *Environmental Pollution, 193*, 119–129.

Ottosson, J., & Grahn, P. (2006). Measures of restoration in geriatric care residences. *Journal of Housing for the Elderly, 19*(3–4), 227–256.

Özünger, H., & Kendle, A. D. (2006). Public attitudes towards naturalistic versus designed landscapes in the city of Sheffield (UK). *Landscape and Urban Planning, 74*, 139–157.

Pearsall, H., & Eller, J. K. (2020). Locating the green space paradox: A study of gentrification and public green space accessibility in Philadelphia, Pennsylvania. *Landscape and Urban Planning, 195*, 103708.

Perek-Białas, J., Sagan, I., Stronkowski, P., & Szukalski, P. (2017). Regional approaches to demographic change in Poland. In C. Martinez, T. Weyman, & J. van Dijk (Eds.). *Demographic transition, labour markets and regional resilience. Advances in spatial science*. Cham: Springer International Publishing.

Pietrzyk-Kaszyńska, A., Czepkiewicz, M., & Kronenberg, J. (2017). Eliciting non-monetary values of formal and informal urban green spaces using public participation GIS. *Landscape and Urban Planning, 160*, 85–95.

Popek, R., Gawrońska, H., Sæbø, A., Wrochna, M., & Gawroński, S. W. (2013). Particulate matter on foliage of 13 woody species: Deposition on surfaces and phytostabilisation in waxes - a 3 year study. *International Journal of Phytoremediation, 15*(3), 245–256.

Poškus, M. S., & Poškienė, D. (2015). The grass is greener: How greenery impacts the perceptions of urban residential property. *Social Inquiry into Well-Being, 1*(1), 22–31.

Przybysz, A., Nersisyan, G., & Gawroński, S. W. (2019). Removal of particulate matter and trace elements from ambient air by urban greenery in the winter season. *Environmental Science and Pollution Research - International, 26*, 473–482.

Pueffel, C., Haase, D., & Priess, J. A. (2018). Mapping ecosystem services on brownfields in Leipzig, Germany. *Ecosystem Service, 30*, 73–85.

Pun, V. C., Manjourides, J., & Suh, H. H. (2018). Association of neighborhood greenness with self-perceived stress, depressive symptoms and anxiety symptoms in older U.S adults. *Environmental Health, 17*(1), 1–11.

PwC (2015). *Reports on major Polish cities*Łódź: PwC Polska Sp. z o.o Poland https://www.pwc.pl/pl/pdf/miasta/raport-o-metropoliach-lodz-2015.pdf, (Accessed date: 24 April 2020).

PwC (2019). *Reports on major Polish cities*Poland: PwC Polska Sp. z o.o. (Accessed date: 24 April 2020) https://www.pwc.pl/pl/publikacje/2019/raport-o-polskich-metropoliach-2019.html.

Rall, E., & Haase, D. (2011). Creative intervention in a dynamic city: A sustainability assessment of an interim use strategy for brownfields in Leipzig, Germany. *Landscape and Urban Planning, 100*, 189–201.

Rall, E., Bielin, C., Zytynska, S., & Haase, D. (2017). Exploring city-wide patterns of cultural ecosystem service perceptions and use. *Ecological Indicators, 77*, 80–95.

Rigolon, A., & Nemeth, J. (2020). Green gentrification or 'just green enough': Do park location, size and function affect whether a place gentrifies or not? *Urban Studies, 557*(2), 402–420.

Rink, D., & Arndt, T. (2016). Investigating perception of green structure configuration for afforestation in urban brownfield development by visual methods—A case study in Leipzig, Germany. *Urban Forestry & Urban Greening, 15*, 65–74.

Rosset, I., Żądzińska, E., Wagner, I., Borowska-Strugińska, B., Lorkiewicz, W., Sitek, A., et al. (2012). Badania pilotażowe związku środowiska urbanizacyjnego łodzi ze statusem społeczno-ekonomicznym rodzin w aspekcie oddziaływania na wybrane parametry morfologiczne dzieci. *Przegląd Pediatryczny, 42*(3), 133–140.

Roy, M., Shemdoe, R., Hulme, D., Mwageni, N., & Gough, A. (2018). Climate change and declining levels of green structures: Life in informal settlements of Dar es Salaam, Tanzania. *Landscape and Urban Planning, 180*, 282–293.

Ruokolainen, L., Fyhrquist, N., & Haahtela, T. (2016). The rich and the poor: Environmental biodiversity protecting from allergy. *Current Opinion in Allergy and Clinical Immunology, 16*(5), 421–426.

Rupprecht, C. D. D. (2017). Informal urban green space: Residents' perception, use, and management preferences across four major Japanese shrinking cities. *Land, 6*(3), 59.

Rupprecht, C. D. D., & Byrne, J. A. (2014a). Informal urban greenspace: A typology and trilingual systematic review of its role for urban residents and trends in the literature. *Urban Forestry & Urban Greening, 13*, 597–611.

Rupprecht, C. D. D., & Byrne, J. A. (2014b). Informal urban green-space: Comparison of quantity and characteristics in Brisbane, Australia and Sapporo, Japan. *PLoS One, 9*(6), e99784.

Rupprecht, C. D. D., Byrne, J. A., Ueda, H., & Lo, A. Y. (2015). 'It's real, not fake like a park': Residents' perception and use of informal urban green-space in Brisbane, Australia and Sapporo, Japan. *Landscape and Urban Planning, 143*, 205–218.

Russo, A., Escobedo, F. J., Cirella, G. T., & Zerbe, S. (2017). Edible green infrastructure: An approach and review of provisioning ecosystem services and disservices in urban environments. *Agriculture, Ecosystems & Environment, 242*, 53–66.

Samuelsson, K., Barthel, S., Colding, J., Macassa, G., & Giusti, M. (2020). *Urban nature as a source of resilience during social distancing amidst the coronavirus pandemic.* OSF Preprints. April 17https://doi.org/10.31219/osf.io/3wx5a.

Sarkar, C., Webster, C., & Gallacher, J. (2018). Residential greenness and prevalence of major depressive disorders: A cross-sectional, observational, associational study of 94,879 adult UK biobank participants. *The Lancet Planetary Health, 2*(4), e162–e173.

Säumel, I., Kotsyuk, I., Hölscher, M., Lenkereit, C., Weber, F., & Kowarik, I. (2012). How healthy is urban horticulture in high traffic areas? Trace metal concentrations in vegetable crops from plantings within inner city neighbourhoods in Berlin, Germany. *Environmental Pollution, 165*, 124–132.

Scholte, S. S. K., van Teeffelen, A. J. A., & Verburg, P. H. (2015). Integrating socio-cultural perspectives into ecosystem service valuation: A review of concepts and methods. *Ecological Economics, 114*, 67–78.

Schroeder, H. W., & Anderson, L. M. (1983). Perception of personal safety in urban recreation sites. *Journal of Leisure Research, 16*(2), 178–194.

Shackleton, C. M., Hurley, P. T., Dahlberg, A. C., Emery, M. R., & Nagendra, H. (2017). Urban foraging: A ubiquitous human practice overlooked by urban planners, policy, and research. *Sustainability, 9*, 1884.

Sikorska, D., Łaszkiewicz, E., Krauze, K., & Sikorski, P. (2020). The role of informal green spaces in reducing inequalities in urban green spaces availability to children and seniors. *Environmental Science & Policy, 108*, 144–154. https://doi.org/10.1016/j.envsci.2020.03.007.

Sikorski, P., Wińska-Krysiak, M., Chormański, J., Krauze, K., Kubacka, K., & Sikorska, D. (2018). Low-maintenance green tram tracks as a socially acceptable solution to greening a city. *Urban Forestry & Urban Greening, 35*, 148–164.

Soga, M., Cox, D. T. C., Yamaura, Y., Gaston, K. J., Kurisu, K., & Hanaki, K. (2017). Health benefits of urban allotment gardening: Improved physical and psychological well-being and social integration. *International Journal of Environmental Research and Public Health, 14*, 71.

Statistical Office in Łódź (2018). *Statistics of Łódź.* Łódź: Statistical Office in Łódź. (Accessed date: 28 April 2020) https://lodz.stat.gov.pl/en/publications/statistical-yearbook/statistics-of-lodz-2018,1,15.html.

Stawasz, D. (2016). Determinants, level and dynamics of the service sector development in Lodz. *Acta Universitatis Lodziensis Folia Oeconomic, 2*(320), 143–160.

Sukopp, H. (2005). Welche Biodiversität soll in Siedlungen erhalten werden? [Which biodiversity should be conserved in urban areas? *CONTUREC, 1*, 15–18.

Szukalski, P. (2012). *Sytuacja demograficzna Łodzi.* Łódź: Wydawnictwo Biblioteka.

Szukalski, P. (2015). Sytuacja demograficzna Łodzi na tle innych wielkich polskich miast. In P. Szukalski (Ed.). *Procesy demograficzne w województwie łódzkim w XXI wieku* (pp. 145–171). Łódź: Wydawnictwo Uniwersytetu Łódzkiego.

Szukalski, P., Martinez-Fernandez, C., & Weyman, T. (2013). *Lódzkie region: Demographic challenges within an ideal location. OECD local economic and employment development (LEED) working papers, 2013/05.* OECD Publishing.

Takano, T., Nakamura, K., & Watanabe, M. (2002). Urban residential environments and senior citizens' longevity in megacity areas: The importance of walkable green spaces. *Journal of Epidemiology and Community Health, 56*, 913–918.

Threlfall, C. G., & Kendal, D. (2018). The distinct ecological and social roles that wild spaces play in urban ecosystems. *Urban Forestry & Urban Greening, 29*, 348–356.

Todorova, A., Asakawa, S., & Aikoh, T. (2004). Preferences for and attitudes towards street flowers and trees in Sapporo, Japan. *Landscape and Urban Planning, 69*, 403–416.

Tyrväinen, L., Ojala, A., Korpela, K., Lanki, T., Tsunetsugu, Y., & Kagawa, T. (2014). The influence of urban green environments on stress relief measures: A field experiment. *Journal of Environmental Psychology, 38*, 1–9.

Unt, A. L., & Bell, S. (2014). The impact of small-scale design interventions on the behaviour patterns of the users of an urban wasteland. *Urban Forestry & Urban Greening, 13*, 121–135.

Van den Berg, A. E., & Koole, S. L. (2006). New wilderness in the Netherlands: An investigation of visual preferences for nature development landscapes. *Landscape and Urban Planning, 78*(4), 362–372.

Van den Berg, A. E., & van Winsum-Westra, M. (2010). Manicured, romantic, or wild? The relation between need for structure and preferences for garden styles. *Urban Forestry & Urban Greening, 9*, 179–186.

Van Renterghem, T. V., & Botteldooren, D. (2016). View on outdoor vegetation reduces noise annoyance for dwellers near busy roads. *Landscape and Urban Planning, 148*,

203–215.
Villeneuve, P. J., Jerrett, M., Su, J. G., Weichenthal, S., & Sandler, D. P. (2018). Association of residential greenness with obesity and physical activity in a US cohort of women. *Environmental Research, 160*, 372–384.
Wagner, I., & Breil, P. (2013). The role of Ecohydrology in creating more resilient cities. *Ecohydrology and Hydrobiology, 13*(2), 113–134.
Wagner, I., & Zalewski, M. (2009). Ecohydrology as a basis for the sustainable city strategic planning: Focus on Lodz, Poland. *Reviews in Environmental Science and Biotechnology, 8*(3), 209–217.
Weber, F., Kowarik, I., & Saumel, I. (2014). A walk on the wild side: Perceptions of roadside vegetation beyond trees. *Urban Forestry & Urban Greening, 13*(2), 205–212.
Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities "just green enough". *Landscape and Urban Planning, 125*, 234–244.
World Health Organization (2016). *Global report on urban health: Equitable healthier cities for sustainable development.* World Health Organization.
Younan, D., Tuvblad, C., Li, L., Wu, J., Lurmann, F., Franklin, M., et al. (2016). Environmental determinants of aggression in adolescents: Role of urban neighborhood greenspace. *Journal of the American Academy of Child and Adolescent Psychiatry, 55*(7), 591–601.